WHOLE-BODY HUMAN-COMPUTER INTERFACE

[0001] This application is a continuation of U.S. application Ser. No. 14/981,414, filed Dec. 28, 2015, which is a continuation of International Application No. PCT/US14/44735, filed Jun. 27, 2014, which claims the benefit of Provisional Application No. 61/843,317 filed Jul. 5, 2013, all of which are incorporated in their entirety herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to virtual reality human-machine interfaces, and more specifically to immersive virtual reality human-machine interfaces. Even more specifically, the present invention relates to immersive virtual reality human-machine interfaces with auditory, visual, proprioceptive, mechanoreceptive, thermoreceptive, and equilibrioceptive modalities.

[0004] 2. Discussion of the Related Art

[0005] Virtual reality systems are computer-based systems that provide experiences to a participant acting in a simulated environment that forms a three dimensional virtual world. These systems are used in several different applications such as commercial flight simulators, entertainment systems, computer games and video arcade games to name a few.

[0006] In virtual reality systems, the participant typically wears a head-mounted device that enables viewing of a virtual reality world generated by the computer. The system also includes an interaction means, such as a pointing device or specially configured glove containing sensors, for interacting with objects in the virtual world. In somewhat sophisticated systems, a data generating body suit, containing sensors and vibrating actuators, may be provided so that the user can influence and receive feedback from objects in the virtual world.

[0007] In recent years, owing to a substantial increase in the performance of digital computing hardware and concomitant software improvements, it has become possible to simulate sophisticated three-dimensional computerized environments. Such "immersive digital environments" have become ubiquitous in modern life, broadly deployed in such diverse fields as entertainment, commerce, training, simulation, visualization, and remote presence. However, despite the rapid evolution of software capabilities, the commercial landscape of human-computer interfaces has changed little since the dawn of the personal computing era. A handful of traditional human-computer interface devices—such as the mouse and keyboard, touch screen, gamepad, and planar visual display—still predominate.

[0008] No known human-computer interface device has yet come close to achieving the long-held goal of enabling fully immersive (i.e. natural, full-body, and pan-sensory) interaction with a computerized environment. A full explication of the shortcomings of the existing state-of-the art is beyond the scope of this document, but a thorough search of the prior art will ascertain in known devices at least one of the following key performance deficiencies, among others:

[0009] Lack of generality: human-computer interfaces of the known art are typically built and programmed for a single narrow range of applications. These systems employ simplified simulation parameters to achieve a design that is conducive to their particular application, but are severely limited in general applicability. Such a design methodology tends to reduce mechanical and computational complexity for many tasks, but at the cost of compromising flexibility, adaptability, and economy of scale of the resultant systems.

[0010] Limited or no integration: human-computer interfaces of the known art generally incorporate only one or a small subset of human sensory modalities. At a minimum, auditory, visual, proprioceptive, mechanoreceptive, thermoreceptive, and equilibrioceptive modalities are required for an acceptable level of immersion, with the addition of the chemosensory (olfactory and gustatory) modality being preferred for increased immersion.

[0011] Only involve a small portion of the body: voluntary movement, the primary means by which humans affect their environment, occurs at virtually every part of the body. Furthermore, the entirety of the skin surface and musculature are embedded with somatosensory organs, which supply critical sensory information. Human-computer interfaces of the known art generally involve only a small portion of the body. Such a design is antithetical to natural simulation of environmental interactions.

[0012] Limited dynamic range and resolution: many human sensory organs are capable of perceiving a large dynamic range of stimulus amplitude and some also have very high spatial and/or temporal resolution. Human-computer interfaces of the known art struggle to match these performance requirements.

[0013] Bulky, heavy, intrusive: human-computer interfaces of the known art are largely too bulky and heavy to be practical, especially those that involve larger portions of the body or integrate multiple sensory modalities. Such interfaces may provide high quality sensory stimulation, but often introduce undesirable noise due to their intrinsic dynamics.

[0014] Even the best performing devices of the known art (and in fact particularly the best performing devices) are simply impractical, as well as being substantially uneconomical. Even if these devices did overcome all of the shortcomings listed above, they would still likely be incapable of broad application due to their prohibitive cost and complexity. Thus, there remains a significant need for an improved human-computer interface device enabling natural, full-body interaction with a computer-mediated environment.

SUMMARY OF THE INVENTION

[0015] In accordance with one embodiment, the present invention can be charactized as a human-computer interface system comprising an exoskeleton including a plurality of structural members coupled to one another by at least one articulation configured to apply a force to a body segment of a user, the exoskeleton comprising a body-borne portion and a point-of-use portion; the body-borne portion configured to be operatively coupled to the point-of-use portion; and at least one locomotor module including at least one actuator configured to actuate the at least one articulation, the at least one actuator being in operative communication with the exoskeleton.

[0016] In accordance with another embodiment, the present invention can be characterized as a method for using the human-computer interface system comprising fitting the user with the body-borne portion of the exoskeleton; permitting an authenticated user to enter a point-of-use enclo-